

**REMARKS****Status of the Claims**

Claims 1 – 67 and 70 – 132 are pending in the application. Claims 1 – 12, 18, 29 – 34, 52 – 64, 66, 67 and 70 – 127 stand rejected. Claims 73 and 77 have been amended. Claims 128 – 132 are new.

Applicants acknowledge the Examiner's allowance of claims 35 – 51 and the indication that claims 13 – 17, 19 – 28, and 65 would be allowable if rewritten in independent form.

**Incorporation of Certificate of Correction Corrections**

The specification was objected to because it does not incorporate the changes made to the disclosure by the Certificate of Correction. Changes to the specification, incorporating the Certificate of Correction corrections have been presented herein.

**Establishment of Ownership Interest in US 5,650,054**

The Examiner has objected to the application under 37 CFR 1.172(a). Assignee submits herewith a Supplemental Certificate Under 37 CFR § 3.73(b), specifying where evidence of chain of title is recorded in the USPTO, in order to satisfy 37 CFR § 3.73.

**Examination of Claims 1, 2, 9 – 12, 29 – 34, 52, 54 and 61 – 65**

The Examiner indicated that the rejections of claims 1, 2, 9 – 12, 29 – 34, 52, 54 and 61 – 65 were affirmed by the Board of Appeals in Reexamination 90/006,209 and thus, that Applicants are not entitled to further adjudication of these claims.

Applicants respectfully submit that these claims should be considered, as Applicants have submitted herewith new evidence (Dr. Shen's Supplemental Declaration of Commercial Success Under 37 CFR § 1.132) in support of the patentability of these claims. The predecessor court to the Federal Circuit has held that claims should be examined when a new record (either amended claims and/or new evidence) present a new

issue from that previously addressed. (See MPEP 706.03(w); *In re Herr*, 377 F.2d 610, 153 USPQ 548 (CCPA 1967) (claims should have been examined even though claims were identical with claims previously held unpatentable on appeal in the parent application; new evidence submitted) and *In re Russell*, 439 F.2d 1228, 169 USPQ 426 (CCPA 1971) (claims should have been examined even though claims were similar to claims as previously appealed; new Rule 132 affidavits submitted).)

Applicants respectfully submit that the new record presents a new issue that entitles Applicants to the further examination of these claims.

**Claims 66, 67 and 70 - 127 are Not Broadened Reissue Claims**

The Examiner rejected claims 66, 67 and 70 - 127 under 35 USC 251 as being broadened in a reissue application after the two-year statutory period. According to MPEP 1412.03(I), a broadened reissue claim is a claim which is greater in scope than each and every claim of the original patent. Applicants respectfully traverse this rejection as follows.

In the preamble of each of claims 66, 67, 73, 76 and 77, the recitation of “for quantitative measurement of a gas” was changed to “for measurement of a gas.” A preamble of a claim is generally not considered to be a limitation to the claim. Specifically, unless it is ‘necessary to give life, meaning, and vitality’ to the claim, the claim preamble should not be construed as if in the balance of the claim. If the preamble merely states, for example, the purpose or intended use of the invention, rather than any distinct definition of any of the claimed invention’s limitations, then the preamble is not considered a limitation and is of no significance to claim construction (see MPEP 2111.02(II), citing to *Pitney Bowes, Inc. v. Hewlett-Packard Co.*, 182 F.3d 1298, 1305, 51 USPQ2d 1161, 1165 (Fed. Cir. 1999)). In this instance, the phrase at issue—“for [quantitative] measurement of a gas”—is merely a statement of purpose or use, not a structural limitation of the claim.

Further, if the body of the claim fully and intrinsically sets forth all of the limitations of the claimed invention, then the preamble is not considered a limitation and is of no significance to claim construction. In other words, a preamble generally is not

limiting when the claim body describes a structurally complete invention such that deletion of the preamble phrase does not affect the structure or steps of the claimed invention (MPEP 2111.02(II), citing to *Catalina Mktg. Int'l v. Coolsavings.com, Inc.*, 289 F.3d 801, 808-09, 62 USPQ2d 1781, 1785 (Fed. Cir. 2002)). In this instance, the body of the claim does not refer back to the phrase at issue, “for quantitative measurement of a gas,” and indeed, the phrase could be eliminated from the preamble without affecting the structure of the claimed invention. Thus, although, in general, the removal of a word or term from a claim would result in a broadening of claim scope, such is not the case in this instance.

In claims 73 and 77, as the Examiner has noted, Applicants omitted the limitation of “the sensing electrode reacting with the gas to produce a change in electrical characteristic between the sensing electrode and the counter electrode.” Applicants apologize for this oversight and herewith amend claims 73 and 77 to include this recitation.

In claims 112 and 126, the phrase “means detects changes” had been changed to “means is capable of detecting changes.” At issue is the recitation:

“whereby, in a positive ambient concentration of said gas, said electrical measurement means is capable of detecting ~~detects~~ changes in said electrical characteristic.”

Applicants made these changes to avoid any possible confusion as to process language—there is no difference in claim scope. The terminology “detects” (as recited in the patent claims) means the same as “capable of detecting” (as recited in the reissue claims). For example, saying that “a vacuum being sold vacuums” does not mean that the vacuum being sold is being used right now, but rather that the vacuum is capable of vacuuming. Thus, a recitation that an electrical measurement means is capable of detecting changes is the same as a recitation that an electrical measurement means detects changes. There is no substantive difference in claim scope when amending “detects” to “capable of detecting.”

In claims 78, 112 and 126, the phrase “electrode reacting with the gas” had been changed to “electrode being capable of reacting with the gas.” At issue is the recitation:

“the sensing electrode being capable of reacting with the gas ...”

Again, Applicants made these changes merely to avoid any possible confusion as to process language—there is no difference in claim scope. The terminology “reacting with” (as recited in the patent claims) need not mean that the sensing electrode is *right now, this very instance*, reacting with the gas. This would be an unreasonably narrow construction of the terminology, particularly within the context of an apparatus claim. When the phrase “reacting with” is given a more reasonable meaning, it is clear that the phrase encompasses “being capable of reacting with” (as recited in the reissue claims). Thus, there is no substantive difference in claim scope when amending “reacting with” to “capable of reacting with.”

A reissue claim is broader than the original patent claims if the reissue claim includes within its scope any conceivable product or process which would not have infringed the original patent. In this instance, there is no sensor that would infringe the reissue claims without also infringing the original patent claims.

#### **Response to Rejections in the Current Office Action**

***i. Claims 6 – 8, 18, 58 – 60, 83 – 85, 95 and 118 – 120***

Claims 6 – 8, 18, 58 – 60, 83 – 85, 95 and 118 – 120 stand rejected under 35 USC 112 as failing to comply with the written description requirement. The Examiner has indicated that Applicants may not have support for an electrode having a film having a thickness in the range of 50-10,000 Å and an electrode comprised of a mixed conductive material. Applicants disagree.

Independent claims 1 and 78, respectively, recite:

“wherein the electrical conducting material of *at least one* of said sensing and counter electrodes is a proton-electron conducting material ...”

Independent claims 52 and 112 include similar recitations.

Claims 6 and 83, which depend from independent claims 1 and 78, respectively, recite:

“*at least one of* the sensing and counter electrodes is comprised of film having a thickness in the range of about 50 Angstroms to 10,000 Angstroms.”

Claims 58 and 118, which depend from independent claims 52 and 112, respectively, recite:

*“at least one of the sensing, counter, and reference electrodes is comprised of film having a thickness in the range of about 50 Angstroms to 10,000 Angstroms.”*

Claims 18 and 95, which ultimately depend from independent claims 1 and 78, respectively, recite:

*“at least one of the first and second pump electrodes is comprised of film having a thickness in the range of about 50 Angstroms to 10,000 Angstroms.”*

Thus, each of the independent claims 1, 52, 78 and 112 recite that *“at least one of said ... electrodes is a proton-electron mixed conductive material ...”* Each of the indicated dependent claims recite that *“at least one of the electrodes is comprised of a film having a thickness ....”* There is no inconsistency in having mixed conductor electrodes and thin film electrodes used in combination in certain embodiments of the sensor. Support for such combinations of electrodes can be found at col. 13, lines 40-50 of the '054 patent:

*“As can be seen either electrode embodiment of FIGS. 6 or 7 can be beneficial. ... As such, it is intended that any of the electrodes of the inventive sensor, in any of the disclosed embodiments herein, may be either a mixed proton electron conductor material electrode or may be a thin film electron conductor material electrode. Further, mixed conductor and thin film electrodes may be used in any combination thereof within any embodiment of the inventive sensor.”*

Thus, Applicants respectfully submit that the recitations of the dependent claims are not inconsistent with the recitations of the independent claims, and are in full compliance with the written description requirement.

***ii. Claims 1, 5, 9, 11, 12, 29 – 34, 52, 53, 57, 61, 63, 64, 67, 71, 73, 75, 77, 78, 82, 86, 88, 89, 106 – 113, 117, 121, 123, 124, 126 and 127 are Patentable under 35 USC 103(a)***

Claims 1, 5, 9, 11, 12, 29 – 34, 52, 53, 57, 61, 63, 64, 67, 71, 73, 75, 77, 78, 82, 86, 88, 89, 106 – 113, 117, 121, 123, 124, 126 and 127 stand rejected as being

unpatentable over Dempsey et al. (US 4,277,984) in view of Uchida et al. (US 5,474,857), Grot et al. (US 5,330,860) and/or Vanderborgh et al. (US 4,804,592). This rejection is respectfully traversed as follows.

a. The Cited Prior Art

Dempsey

Dempsey discloses flooding one side of a solid polymer electrolyte membrane with distilled water. Specifically, a water channel 7, connected to reservoir 1 via hydrated ports 5 and 6, is positioned over an ionically conductive, hydrated SPE bridge 8 formed on the upper surface of membrane 9. (See Fig. 1; col. 4, lines 30-46.) Further, Dempsey expressly discloses that “the surface of the counter electrode and the membrane area around the electrode is flooded.” (Col. 4, lines 46-49.)

Dempsey’s principle of operation relies on flooding one side of the membrane with distilled liquid water. Dempsey discloses that this flooding of the membrane with distilled water provides “self-humidification,” i.e., transport of water in the vapor phase across the membrane. (Col. 7, lines 50-54, referring to Nolan et al. (US 4,171,253) which discloses, at col. 3, lines 22-26, that “this self-humidifying arrangement is possible in SPE-type gas sensor by maintaining the side of the SPE membrane away from the gas side, i.e., away from the side containing the sensing electrode flooded with distilled water.”) Dempsey further discloses that by eliminating the possibility that the membrane will dry out and by providing an ionically conductive, hydrated SPE bridge, the output current from the device is improved. (Col. 3, line 64 to col. 4, line 10.) Thus, Dempsey teaches that flooding one side of the membrane with distilled liquid water is important for its principle of operation.

With respect to the electrodes, Dempsey discloses that the electrodes are each “a bonded mass of particles of a platinum-5% iridium alloy and *hydrophobic* particles such as polytetrafluoroethylene.” (Col. 5, lines 29-33; see also, col. 7, lines 25-31; col. 7, line 65 to col. 8, line 4; col. 8, lines 27-29. Emphasis added.) Dempsey further discloses that “the nature and characteristics of an electrode, comprising a mixture of particles of a gas absorbing noble metal bonded with particles of *hydrophobic* material as well as the

process for doing so, are described in detail in U.S. Pat. No. 3,432,355 ["Niedrach"] ...." (Col. 8, lines 31-44. Emphasis added.) Niedrach, in turn, discloses that the electrodes are purposely made *hydrophobic* to prevent flooding/drowning<sup>1</sup> of the electrode when in contact with water:

The electrodes comprise gas absorbing metal particles bonded together into a cohesive mass with polytetrafluoroethylene and having a coating of polytetrafluoroethylene bonded to the electrode surface in contact with the gas phase. These novel electrode structures, when used in combination with the aqueous electrolyte ... do not require special fabrication or additional precautions to prevent the electrolyte from flooding the surface of the electrode in contact with the gas phase, and thereby "drowning" the electrode which would deleteriously affect the performance of the fuel cell reaction." (Col. 1, lines 19-30.)

Thus, Dempsey discloses (via its citation to Niedrach and its repeated express disclosure that the electrode binder is hydrophobic) that its electrodes are impervious to the water such that flooding/drowning of the electrode does not occur.

In sum, Dempsey teaches the necessity that the counter electrode be surrounded with distilled liquid water in order to keep the membrane and the ionically conducting bridge on the membrane hydrated. Dempsey further teaches the necessity that the

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<sup>1</sup> "Flooding" refers to the penetration of electrolyte into hydrophobic regions of the catalyst layer which should contain only gas. This misplaced liquid hinders and may totally obstruct the supply of reactant gas to local regions of the catalyst. As a result there is an increase in electrode polarization as the non-flooded regions of the electrode are forced to carry more current. The process is self-propagating and will eventually lead to cell failure. In fuel cells having an acid electrolyte the flooding phenomenon is most prevalent at the cathode i.e., at the water-producing electrode. (See WO/1993/003505) High Current Acid Fuel Cell Electrodes.)

See also, EP0046086: "Early in the development of electrodes for fuel cells it was realised that porous, hydrophobic electrodes were desirable especially for use as a hydrogen anode in order to achieve proper control of electrode wetting and to prevent flooding thereof by the electrolyte so that both the reaction gases and the electrolyte had satisfactory access to the electro-catalyst in the electrode."

electrode be hydrophobic so that drowning of the electrode in the aqueous environment does not occur.<sup>2</sup>

Uchida, Grot and Vanderborgh

The Examiner has cited to Uchida, Grot and Vanderborgh because each of these references teach, in the context of fuel cells and/or electrolytic cells, the addition of Nafion<sup>®</sup> to an electrode composition.

However, a person of ordinary skill in the art at the time of the invention would have known that the addition of Nafion<sup>®</sup> to an electrode composition would make the electrode non-hydrophobic. For example, US 5,599,638 to Surampudi et al. (filed October 12, 1993, and thus indicative of the knowledge of a person of ordinary skill in the art at the time of the invention) discloses that two major categories of electrodes exist: gas-diffusion type electrodes and liquid-feed type electrodes (col. 2, lines 35-48). Surampudi discloses that electrodes formed of carbon-supported alloy [catalyst] powder and a Teflon<sup>®</sup> binder yield a gas diffusion electrode (col. 2, lines 25-27). According to Surampudi, gas-diffusion type electrodes, which have poor fuel wetting properties, can be modified for use in liquid feed cells by including substances that improve their wetting properties, *e.g.*, Nafion<sup>®</sup> (col. 4, lines 10-21). Surampudi discloses that the addition of Nafion<sup>®</sup> to an electrode composition allows the liquid surrounding the electrode to flow into or wet the pores, thus creating a liquid-feed type electrode. In other words, Surampudi teaches that electrodes having poor wetting properties (*i.e.*, hydrophobic electrodes) can be converted to electrodes having good wetting properties (*i.e.*, non-hydrophobic electrodes) by the addition of Nafion<sup>®</sup>.

Thus, Uchida, Grot and Vanderborgh, by disclosing the addition of Nafion<sup>®</sup> to the electrode compositions, all disclose liquid-fuel type electrodes, *i.e.*, electrodes that will allow water to penetrate their pores.<sup>3</sup>

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<sup>2</sup> Further, with respect to the Examiner's assertion on page 7 of the Office Action that Dempsey recognizes that electrodes set forth in the fuel cell prior art would find utility in the sensor of Dempsey (citing to col. 8, lines 30-63, as justification for citing to Uchida, Vanderborgh or Grot), Applicants submit that this recognition by Dempsey of fuel cell prior art electrodes is limited to **hydrophobic** electrodes, such as those taught by Niedrach.



Uchida

Uchida fails to disclose electrodes having the claimed composition, i.e., a proton-electron mixed conductive material having 10-50 wt % of a proton conductor material and 50-90 wt % of a first and a second electrical conductor material.

Example 1 of Uchida discloses that 1g of Nafion<sup>®</sup> polymer was added to 60g of n-butyl acetate to form a colloidal dispersion. Then 50g of Pt-C (having 10-25% platinum catalyst) were added to this colloidal dispersion. The resulting paste was coated on carbon paper. Thus, the disclosed electrode of example 1 has 2.0 wt% proton conductor material (1g Nafion<sup>®</sup> / (1g Nafion<sup>®</sup> + 50g Pt-C)) and 98 wt% electrical conductor material (50g Pt-C / (1g Nafion<sup>®</sup> + 50g Pt-C)).

Examples 2-6 maintain the same solids ratios, merely swapping out the organic solvents.

Example 7 adds an additional 25g of carbon powder (having 25-70 wt% PTFE) to the colloidal dispersion. Thus, the disclosed electrode of example 7 has 1.3 wt% proton conductor material (1g Nafion<sup>®</sup> / (1g Nafion<sup>®</sup> + 50g Pt-C + 25g C/PTFE)) and 75.7 wt% to 90.4 wt% electrical conductor material ((50g Pt-C + 30% to 75% of (25g C/PTFE)) / (1g Nafion<sup>®</sup> + 50g Pt-C + 25g C/PTFE)).

Thus, while the claims require 10-50 wt % of a proton conductor material, none of the inventive examples of Uchida have a wt % of Nafion<sup>®</sup> that exceeds 2.0 wt %.

Uchida's comparative example is disclosed at col. 7, line 54 to col. 8, line 7. Uchida's comparative example does not explicitly disclose the amounts of the Pt-C component (10-25 wt% platinum) or of the C/PTFE component (25-70 wt% PTFE). Uchida discloses that the Pt-C and the C/PTFE are sprinkled on carbon paper and hot pressed to form an electrode. This hot pressed Pt-C with C/PTFE layer does not include a proton conductor material.

At the top of col. 8, in a new paragraph, Uchida discloses that a *coat* of Nafion<sup>®</sup> is applied to the previously hot-pressed catalyst layer of the electrode. In other words, in

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<sup>3</sup> A liquid-fuel type electrode can be used in a non-liquid environment and operated as a gas-diffusion electrode. However, if a liquid-fuel type electrode is used in a liquid environment, it cannot then operate as a gas-diffusion electrode, as its pores will be flooded.

the comparative example, Uchida discloses that the Nafion<sup>®</sup> coat is a separate layer formed on the electrode after the electrode has been hot pressed. This separate Nafion<sup>®</sup> layer does not include any electrical conductor material.

Thus, with respect to the comparative example, Uchida fails to disclose any material having a proton-electron mixed conductive material. Rather, Uchida discloses two material layers: the hot pressed Pt-C with C/PTFE layer (and with no proton conductor material) and the Nafion<sup>®</sup> layer (with no electrical conductor material). These two distinct layers do not form a single proton-electron mixed conductive material as required by the claims of the instant application.

And, in fact, this is exactly the point of Uchida's comparative example—to compare the separate Nafion<sup>®</sup> and carbon layers of the comparative example to Uchida's inventive examples, which have a low level of Nafion<sup>®</sup> mixed in with the electrical conductor material. Given this, it is irrelevant what weight percent this separate Nafion<sup>®</sup> proton conductive layer has relative to the Pt-C with C/PTFE electron conductive layer.

Thus, neither Uchida's inventive examples (Examples 1-7) nor Uchida's comparative example disclose a proton-electron mixed conductive material having 10-50 wt % of a proton conductor material.

#### Vanderborgh

Vanderborgh fails to disclose electrodes having the claimed composition, i.e., an electrical conducting material that is a proton-electron mixed conductive material having 10-50 wt % of a proton conductor material and 50-90 wt % of a first and a second electrical conductor material.

Vanderborgh discloses that an object of the invention is to provide a composite electrode which is constructed to have increasing electronic conductivity from the catalyst loading zone to a current collector on one face of the electrode, and to have increasing protonic conductivity from the zone of the catalyst loading to the face of the electrode which engages the ion exchange membrane. (Col. 3, lines 37-44).

Vanderborgh accomplishes this by providing an electrode comprised of three zones or layers. Referring to FIG. 2, Vanderborgh discloses that the composite electrode is formed of three separate layers (22, 24 and 26) thermally bonded to each other (col. 8,

lines 13-15; col. 8, lines 59-62). Each layer comprises a mixture of carbon black, platinum, PTFE and a suitable ionic conducting material (col. 8, lines 16-20).

Table I discloses the compositional parameters for each layer. Layer 22 has a proton conducting material weight percent of 4.3% (.021/.491) and an electrical conducting material weight percent of 82.3% (.304/.491). Layer 24 has a proton conducting material weight percent of 4.4% (.119/2.718) and an electrical conducting material weight percent of 91.2% (2.48/2.718). Layer 26 has a proton conducting material weight percent of 74% (.422/.570) and an electrical conducting material weight percent of 12.1% (.069/.570). None of these layers has 10-50 wt % of a proton conductor material and 50-90 wt % of a first and a second electrical conductor material, as required by the claims.

Further, it would be improper to consider the entire composite electrode of Vanderborgh as a single electrical conducting material, i.e., to consider the three separate layers 22, 24, 26 to be a single material. Each separate layer of the electrode is a distinct material—bonding the layers together does not form a new “material.”

#### Grot

In the example referred to by the Examiner, Grot discloses using a non-hydrophobic binder (Nafion<sup>®</sup>) for its fuel cell electrode (col. 14, lines 15-27). In addition to the teachings of Surampudi, discussed above, (i.e., that the addition of Nafion<sup>®</sup> to an electrode composition creates a non-hydrophobic, liquid-fuel type electrode), Grot expressly discloses that the electrode is a “gas-*liquid* permeable porous electrode.” (Col. 1, lines 31-32; emphasis added.) Thus, Grot explicitly discloses that its electrode is a liquid-fuel type electrode, i.e., an electrode that is specifically designed to allow the penetration of the liquid into the pores of the electrode.

Grot further explicitly discloses that its membrane and electrode structure is useful in electrolytic cells where, for example, the anode electrolyzes an aqueous solution. Thus, again Grot discloses that the electrode may be a liquid-fuel type electrode (col. 13, lines 35-50).

b. The Proposed Combination of References Changes Dempsey's Principle of Operation and, in fact, Renders Dempsey Unsatisfactory for its Intended Purpose

The Examiner has indicated that it would have been obvious to utilize the teachings of Uchida, Grot and/or Vanderborgh for the sensor of Dempsey. Applicants disagree.

If one were to replace the hydrophobic electrodes, as expressly taught by Dempsey, with non-hydrophobic electrodes as taught by Grot (or Uchida, or Vanderborgh), Dempsey's principle of operation would be changed. In fact, Dempsey would be rendered inoperable or, at the very least, unsatisfactory for its intended purpose due to flooding of the electrodes of Grot (or Uchida, or Vanderborgh).

Dempsey teaches a gas sensor that uses a gas permeable (i.e. a gas-diffusion type) electrode. However, Dempsey also teaches surrounding the area of the counter electrode with distilled liquid water. Dempsey then further explicitly and repeatedly teaches using a hydrophobic binder for the electrodes. (Col. 8, lines 34-44.) Niedrach (cited by Dempsey to disclose the electrodes used in the gas sensor of Dempsey and the process of making these electrodes) explicitly teaches using hydrophobic electrodes so that the electrodes will not "drown" in an aqueous environment (col. 1, lines 19-30). In essence, Dempsey teaches away from using a non-hydrophobic binder for the electrodes.

Uchida discloses including a non-hydrophobic binder (Nafion<sup>®</sup>) in its fuel cell electrodes.

Vanderborgh discloses including a non-hydrophobic binder (Nafion<sup>®</sup>) in its fuel cell electrodes.

Grot discloses including a non-hydrophobic binder (Nafion<sup>®</sup>) in its fuel cell electrodes.

Surampudi teaches that the inclusion of Nafion<sup>®</sup> in the electrode composition converts a gas-diffusion type electrode into a liquid-fuel type electrode.

A person of ordinary skill the art would realize that replacing Dempsey's gas-diffusion type, hydrophobic electrodes with a liquid-fuel type electrode as taught by Grot (or Uchida, or Vanderborgh) would result in the electrodes being flooded/drowned with the distilled water, such that the gas to be reacted would be unable to reach the reaction sites within the electrodes. (See discussion of Surampudi, above.) In essence,

Dempsey's gas sensor would be unable to sense or react to the gas. Thus, contrary to the Examiner's assertion, as the combination renders Dempsey's sensor inoperable, one of ordinary skill in the art would have reason to NOT replace the hydrophobic electrodes of Dempsey with the non-hydrophobic electrodes of Grot (or Uchida, or Vanderborgh).

c. The Proposed Combination of References Fails to Disclose Each and Every Element of the Claimed Invention

Dempsey discloses surrounding the counter electrode with *liquid water*. However, the claims require "means, containing a volume of *water vapor*, for exposing a surface of said counter electrode to said water vapor." Dempsey fails to disclose that the counter electrode is exposed to water vapor.

It appears that the Examiner is simply equating Dempsey's disclosure of liquid water as a disclosure of water vapor. However, in the context of solid polymer electrolyte membranes, it has long been known in the art that these membranes respond dramatically differently when exposed to liquid water as opposed to water vapor. This different response is referred to as "Schroeder's paradox."<sup>4</sup> Basically, the water-uptake of a polymer electrolyte membrane, such as Nafion<sup>®</sup>, exposed to liquid water is significantly greater than the water-uptake of the same membrane exposed to 100% relative humidity water vapor. For example, the water-uptake is approximately 30 wt % with liquid water at room temperature and 15 wt % at 100% relative humidity.<sup>5</sup>

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<sup>4</sup> "In polymer electrolyte membranes such as Nafion<sup>®</sup> the increasing uptake of water strongly depends on the equilibration with water vapor or liquid water. Usually, with increasing relative humidity, water-uptake also increases. If such a membrane is brought into contact with liquid water, instead of water vapor saturated gas, the water-uptake increases dramatically (e.g., water-uptake is approximately 15 wt. % at 100% RH and 30 wt. % with liquid water at room temperature). This is generally known as Schroeder's paradox." US Published Patent Application No. 2007/0178341, "Gas channel coating with water-uptake related volume change for influencing gas velocity," to Wieser, published August 2, 2007. *See also*, 2007: Onishi L. et al., "Water-Nafion Equilibria. Absence of Schroeder's Paradox," The Journal of Physical Chemistry, B 2007;111(34):10166-73 ("Numerous water uptake studies have been conducted,<sup>3-5, 8, 10, 12-16</sup>) [Hereinafter "Onishi"; summary found at [http://ecsmee6.peerxpress.org/ms\\_files/ecsmee6/2007/05/21/00001757/00/1757\\_0\\_art\\_0\\_jieoej.pdf](http://ecsmee6.peerxpress.org/ms_files/ecsmee6/2007/05/21/00001757/00/1757_0_art_0_jieoej.pdf) and supplied herewith.]

<sup>5</sup> *Id.*

As discussed above, Dempsey explicitly discloses that the counter electrode side of the solid polymer electrolyte membrane is “flooded with distilled water,” particularly in the area where the Dempsey’s membrane was specially treated with boiling water to create “a swollen, hydrated, ionically conductive SPC bridge.” Dempsey teaches that the flooding of one side of the membrane with distilled water is important for its principle of operation.

Schroeder’s paradox teaches that water vapor is not equivalent to liquid water in the context of hydration of Nafion® membranes. Thus, a person of ordinary skill in the art would recognize that replacing the liquid water of Dempsey with water vapor would, among other things, reduce the hydration of the swollen membrane bridge that Dempsey went to special lengths to achieve and would degrade the current output of Dempsey’s sensor. Even further, Onishi (see footnote 4) teaches that “[m]embrane water content dramatically affects membrane transport properties, such as proton conductivity and water diffusion coefficient.”

The claims require that the surface of the counter electrode is exposed to water vapor. Dempsey fails to disclose that the counter electrode is exposed to water vapor. Grot (or Uchida, or Vanderborgh) fail to cure this deficiency. Thus, each and every element is not disclosed by the cited combination of references.

Further, the Examiner has failed to provide any rationale as to why one of ordinary skill in the art would consider Dempsey’s disclosure of liquid water as a disclosure of water vapor. Nor has the Examiner provided any rationale as to why one would replace the liquid water of Dempsey with water vapor. And indeed, Applicants submit that replacing the liquid water of Dempsey with water vapor would render Dempsey unsatisfactory for its intended purpose. Thus, Applicants respectfully submit that the Examiner has failed to provide a clear articulation of why the cited references would have rendered the claimed invention obvious as required by *KSR Int’l Co. v. Teleflex Inc.*, 82 USPQ2d 1385, 1395-97 (2007) and MPEP 2143.

*iii. Claims 2, 54, 79 and 114 are Patentable under 35 USC 103(a)*

Claims 2, 54, 79 and 114 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dempsey in view of Grot, Uchida and/or Vanderborgh as applied to claims 1, 52, 78 and 112 above, and further in view of La Conti et al. (US 4,820,386). The rejection is respectfully traversed for the reasons discussed below.

The Examiner has failed to provide a clear articulation, as required by KSR, as to why LaConti's disclosure should be combined with Dempsey.

Claims 2, 54, 79 and 114 each recite that the water vapor containing means contains a volume of water and an antifreeze additive.

As an initial matter, LaConti fails to cure the deficiencies of Uchida, Grot and Vanderborgh discussed above.

Further, as also discussed above, Dempsey expressly teaches the importance of having one side of its solid polymer electrolyte membrane flooded with distilled water. In particular, Dempsey teaches that an ionically conductive, hydrated bridge between the sensing and reference electrodes enhances the current output (col. 3, line 64 to col. 4, line 10). Dempsey discloses that this hydrated bridge is formed using a special technique (exposing the bridge area to boiling water, three times) and that this specially swollen, hydrated bridge is flooded with distilled water.

LaConti discloses a sensor cell having a proton-conducting membrane with sensing and counter electrodes located on the same side of the membrane. Fig. 1 discloses that the membrane is hydrated with a water reservoir on the side of the membrane opposite to the sensing and counter electrodes. LaConti then further discloses that the membrane can be hydrated using water vapor instead of liquid water so long as the relative humidity in the vicinity of the cell membrane is maintained above 80%. (Col. 11, lines 34-41.) LaConti discloses that a water vapor transport film, allowing only the passage of pure water vapor, may be inserted between the cell membrane and the water source, thereby allowing for the use of impure water (e.g., water with glycol). (Col. 11, lines 42-53.)

LaConti, in contrast to Dempsey, fails to disclose that a swollen, ionically conductive, hydrated SPE bridge is formed on the surface of the electrolyte membrane.

Thus, LaConti's disclosure that water vapor at or above 80% relative humidity may be used in LaConti's invention in place of liquid water is not a disclosure that water vapor may be used in place of liquid water in Dempsey's invention. In fact, Schroeder's paradox, as discussed above, teaches that the water uptake of the solid polymer electrolyte membrane from water vapor would be significantly less than the water uptake from liquid water. A person of ordinary skill in the art would not equate exposing Dempsey's swollen, ionically conductive, hydrated SPE bridge to liquid water with exposing Dempsey's hydrated SPE bridge to water vapor.

Even further, providing a water vapor transport film between the reservoir and the solid polymer electrolyte membrane, as disclosed in LaConti, would defeat Dempsey's disclosure that the electrolyte membrane be flooded with liquid water.

As there is no rationale presented as to why a person of ordinary skill in the art would combine LaConti's disclosure (of replacing liquid water with water vapor or inserting a water vapor transport film between the reservoir and the solid polymer electrolyte membrane) with Dempsey's disclosure (of flooding the solid polymer electrolyte membrane and its hydrated SPE bridge with liquid water), Applicants respectfully submit that claims 2, 54, 79 and 114 are patentable over the cited references.

***iv. Claims 3, 55, 80 and 115 are Patentable under 35 USC 103(a)***

Claims 3, 55, 80 and 115 are rejected under 35 USC 103(a) as being unpatentable over Dempsey in view of Grot, Uchida and/or Vanderborgh as applied to claims 1, 52, 78 and 112 above, and further in view of Hielscher et al. (US 5,403,452). The rejection is respectfully traversed for the reasons discussed below.

As an initial matter, Hielscher fails to cure the deficiencies of Dempsey, Uchida, Grot and Vanderborgh discussed above.

Claims 3, 55, 80 and 115 each recite, among other things, that the surface of the sensing electrode that is exposed to the ambient atmosphere has a surface area smaller than the surface area of the surface of the counter electrode that is exposed to said water vapor.



Hielscher discloses a sensor for determining the gas concentrations in a mixture of gases. The sensor has a solid electrolyte provided with measuring, counter and reference electrodes.

The principle of operation of Hielscher's sensor is almost diametrically opposed to the principle of operation of Dempsey's sensors. For example, Hielscher explicitly teaches against the use of "watery electrolytes or polymeric solid electrolytes" (referring to Dempsey, col. 1, lines 11-31). Further, in contrast to Dempsey, Hielscher expressly discloses that its solid electrolyte cannot transfer or accept the gas component to be detected. (Col. 3, lines 41-42 and col. 4, lines 57-59.) Even further, in contrast to Dempsey, Hielscher discloses that the electrodes are inert to the gas (col. 3, lines 42-46; col. 7, lines 36-38). Hielscher also discloses, in contrast to Dempsey, that the ions of the solid electrolyte combine with the different gas components (col. 6, lines 11-15), thereby forming salts at the electrolyte/electrode/gas boundary. Hielscher further discloses that contrary to the electrolyte that has a solubility for the electrochemical reaction product, in the case of a solid cat-ionic electrolyte, the reaction product [i.e., the salt] has to be electrochemically decomposed. (Col. 4, lines 6-9.)

Hielscher is particularly concerned with the prevention of the formation of a permanent layer of metal salt on the measuring electrode. (Col. 4, lines 13-43 and lines 46-51.) Thus, Hielscher teaches limiting the formation of the salts in the first place and electrochemically decomposing any such salts that do form on the measuring electrode. To electrochemically decompose any salts that do form, Hielscher discloses limiting the current density at the surface of the measuring electrode where the layer of salt is formed to below a certain amount. (Col. 4, lines 39-43 and col. 5, lines 18-23.) It is within this context, that Hielscher discloses that the electrochemically effective current density at the counter electrode should be smaller than that at the measuring electrode. (Col. 8, lines 29-44.) In contrast, Dempsey has no such concerns.

Hielscher is not concerned with whether or not the counter electrode diffusion-limits the response. Hielscher is concerned with decomposing salts that form at the measuring electrode. As such, there is no valid rationale for applying Hielscher's

disclosure regarding the relative sizes of the counter or measuring electrode to the gas sensor of Dempsey.

Given the vast disparity in the principles of operation between Dempsey and Hielscher, a person of ordinary skill in the art would have no reason to apply the teachings of Hielscher, as to the formation or regeneration of salts, to the gas sensor of Dempsey.

**v. *Claims 4, 56, 81 and 116 are Patentable under 35 USC 103(a)***

Claims 4, 56, 81 and 116 are rejected under 35 USC 103(a) as being unpatentable over Dempsey and Hielscher in view of Grot, Uchida and/or Vanderborgh as applied to claims 3, 55, 80 and 115 above, and further in view of La Conti. The rejection is respectfully traversed for the reasons discussed below.

Claims 4, 56, 81 and 116 each recite, among other things, that the surface area of the surface of the counter electrode that is exposed to said water vapor is separated from said means for exposing a surface of said counter electrode to said water vapor by a hydrophobic membrane permeable to water vapor and substantially impervious to water.

As discussed above with respect to the rejections of claims 2, 54, 79 and 114, LaConti fails to cure the deficiencies of Dempsey, Uchida, Grot and Vanderborgh. Specifically, among other things, Applicants have shown that combining Uchida, Grot and/or Vanderborgh and LaConti with Dempsey would render Dempsey inoperable or, at the very least, unsatisfactory for its intended purpose.

Further, as discussed above, with respect to claims 3, 55, 80 and 115, it is improper to combine the disclosure of Hielscher with Dempsey as the principles of operation of the Hielscher and Dempsey sensors are completely disparate.

**vi. *Claims 10, 62, 66, 70, 72, 74, 76, 87 and 122 (and claims 67, 73 and 75 in the alternative) are Patentable under 35 USC 103(a)***

Claims 10, 62, 66, 70, 72, 74, 76, 87 and 122 (and claims 67, 73 and 75 in the alternative) are rejected under 35 USC 103(a) as being unpatentable over Dempsey in view of Grot, Uchida and/or Vanderborgh as applied to claims 1, 52, 78 and 112 above,

and further in view of Tomantschger et al. (US 5,302,274). The rejection is respectfully traversed for the reasons discussed below.

As an initial matter, claims 10, 62, 66, 70, 72, 74, 76, 87 and 122, and claims 67, 73 and 75, all recite or depend from claims that recite “wherein the electrical conducting material of at least one of said sensing and counter electrodes is a proton-electron mixed conductive material having 10-50 wt % of a proton conductor material and 50-90 wt % of a first and a second electrical conductor material.” Tomantschger fails to cure the deficiencies of Dempsey combined with Uchida, Grot and/or Vanderborgh, as discussed above with respect to this recitation. Thus, for at least the reasons discussed above, these claims are patentable.

Further, claims 66, 70, 72, 74 and 76 each recite that the sensing and counter electrodes are the only two electrodes in contact with the electrolyte membrane.

The Examiner has indicated that Tomantschger teaches that it is unnecessary to have three electrodes for the gas sensor as only two are necessary for sensor operation. Applicants submit that Tomantschger’s teachings are not relevant to or combinable with Dempsey’s teachings, and further, Applicants submit that Dempsey teaches that three electrodes are necessary for its principle of operation.

Applicants respectfully submit that Tomantschger’s disclosure as to a two-electrode sensor is not relevant to Dempsey’s sensor, and in particular, is not germane to Dempsey’s disclosure concerning its reference electrode. Specifically, *Dempsey uses its reference electrode to account for temperature variations during zero-air operations*. Tomantschger fails to disclose that its two-electrode configuration can account for temperature variations during zero-air operations. Thus, it is improper to apply Tomantschger’s teaching of a sensor without a reference electrode to Dempsey’s disclosure of a temperature invariant sensor. At the very least, Tomantschger’s disclosure that two-electrode sensors may be commensurate with three-electrode sensors under certain operating conditions and functional requirements, is not applicable to Dempsey where the functional requirements differ from Tomantschger’s. Indeed, if one were to eliminate the reference sensor from Dempsey, as disclosed by Tomantschger, Dempsey’s

sensor would no longer be operative for its disclosed purpose—i.e., stable zero-air operation under changing temperature conditions.

Specifically, Dempsey discloses that a reference electrode 11 is provided on the same surface as the sensing electrode to eliminate large background current variations with *temperature variations* during zero-air operations. *See*, Title; col. 1, lines 24-37; col. 2, lines 6-13; col. 4, lines 11-29; col. 4, line 67 – col. 5, line 5; and col. 6, lines 10-12 and lines 30-37. The reference electrode is positioned as close as possible to the sensing electrode, while being maintained remote from the flux lines between the sensing and counter electrodes, *so that the reference and sensing electrodes may be subjected to the same temperature conditions*. Col. 4, lines 11-29 and col. 6, lines 10-12. Further, Dempsey discloses using a potentiostatic circuit to maintain the potential of the sensing electrode at a desired level and to maintain a fixed potential difference between the sensing electrode and the reference electrode to permit invariant and accurate operation with time and *with changes in temperature*. Col. 4, line 67 – col. 5, line 5.

In contrast, Tomantschger appears to simply assume that, in the absence of the contaminant gas, a specific or known electrical potential (which could be zero) will be developed between the sensor electrode 12 and the counter electrode 16. (Col. 11, lines 12-26.) Thus, with respect to the two-electrode configuration, Tomantschger fails to recognize that temperature variations may cause the electrical potential between the sensor and counter electrodes to change. Tomantschger fails to even recognize the problem that Dempsey's reference electrode is meant to solve.

Further, in contrast to Dempsey, in the three-electrode configuration Tomantschger fails to disclose the use of the reference electrode to maintain the potential of the sensor electrode to account for changes in temperature. Rather, Tomantschger (referring to FIG. 6) discloses a potentiometric measurement means is provided between the reference electrode and the sensor electrode. In other words, Tomantschger *measures* the potential between the reference and sensor electrodes—Tomantschger does not *maintain* the potential of the sensor electrode. Thus, as Tomantschger apparently uses a reference electrode for a different purpose than Dempsey uses a reference electrode,

Tomantschger's disclosure that the reference electrode need not be used under certain conditions is inapposite to Dempsey's disclosure.

Even further, Tomantschger discloses that when a two-electrode configuration is used (refer to FIGS. 2, 3, 4, 5 and 7), the counter electrode is mounted so as to be exposed to an enclosed volume of scrubbed or otherwise uncontaminated air or gas (such as nitrogen). (Col. 10, lines 11-19.) Tomantschger further explicitly discloses that in the two-electrode configuration it is the specific voltage between the sensor and counter electrode that is the desired characteristic to measure, i.e., that a change of that voltage is indicative of the presence of a contaminant gas being tested for. (Col. 11, lines 27-40.) However, when Tomantschger discloses a three-electrode configuration (refer to FIG. 6), it appears that now the desired characteristic measured between the sensor and the counter electrode is the current and that the counter electrode is no longer exposed to the volume of scrubbed air. Thus, Tomantschger teaches that the functionality of the counter electrode and the circuitry arrangement of the two-electrode sensor significantly differs from the functionality of the counter electrode and the circuitry arrangement of three-electrode sensor.

As the Examiner has recognized that Dempsey fails to disclose that the sensing electrode and the counter electrode are the only two electrodes, and as Tomantschger, as discussed above, fails to disclose that the reference electrode of Dempsey could be eliminated without disrupting the principle of operation of Dempsey, the combination of Dempsey in view of Tomantschger fails to render claims 66, 70, 72, 74 and 76 unpatentable.

Claims 67, 73 and 75 were rejected in the alternative. Claim 67 includes the recitation of "the sensing electrode reacting with the gas to produce a change in an electrical characteristic between the sensing electrode and the counter electrode in the absence of an applied voltage to the sensing electrode." Claims 75 includes a similar recitation. Claim 73 recites "in the absence of any biasing voltage."

Dempsey expressly teaches that "the voltage [of the sensing electrode] should not be allowed to fall below approximately 1.0 volts in order to maintain an oxide coating on

the surface of the catalytic sensing electrode to prevent CO poisoning of the electrode and to prevent reduction of oxygen at the electrode or other competing reactions which introduce error currents.” (Col. 10, lines 3-9.) In other words, *Dempsey expressly teaches that its sensor electrode would be poisoned by CO in the absence of a maintained voltage of 1.0 or greater.* Tomantschger fails to disclose that its sensor would not be subjected to CO poisoning.

In fact, Tomantschger, referring to the two-electrode embodiment of FIG. 7, expressly discloses that a specific voltage is developed and maintained between the sensor electrode and the counter electrode (col. 11, lines 3-6).

In light of this express teaching and in the absence of any teaching as to why the electrodes of Vanderborgh, Uchida and/or Grot would not be poisoned by CO, Applicants submit that a person of ordinary skill in the art would not have combined the cited references such as to render claims 67, 73 and 75 unpatentable.

**vii. Claims 66, 70, 72, 74 and 76 are Patentable under 35 USC 103(a)**

Claims 66, 70, 72, 74 and 76 are rejected under 35 USC 103(a) as being unpatentable over Dempsey in view of Grot, Uchida and/or Vanderborgh as applied to claims 1, 52, 78 and 112 above, and further in view of Nagata et al. (US 4,913,792). This rejection is respectfully traversed for the reasons discussed below.

As an initial matter, Nagata fails to cure the deficiencies of Dempsey combined with Uchida, Grot and/or Vanderborgh as discussed above.

Nagata, a newly cited reference, is relied upon by the Examiner for allegedly teaching an alternative, three-electrode gas sensor that is equivalent to the three-electrode gas sensors of Dempsey, and for further teaching that Nagata’s three-electrode sensor could be constructed without the presence of a reference electrode (OA, p. 14).

Applicants respectfully submit that Nagata’s disclosure as to eliminating a reference electrode is not relevant to Dempsey’s sensor, and in particular, is not germane to Dempsey’s disclosure concerning its reference electrode. Specifically, *Dempsey uses its reference electrode to account for temperature variations during zero-air operations*, whereas *Nagata uses the reference electrode to account for a drifting counter electrode*

potential due to the reduction/oxidation reactions. Nagata's reference electrode is not used to account for temperature variations. Thus, it is improper to apply Nagata's teaching of a sensor without a reference electrode to Dempsey's temperature invariant sensor. At the very least, Nagata's disclosure that two-electrode sensors may be commensurate with three-electrode sensors under certain operating conditions and functional requirements, is not applicable to Dempsey where the functional requirements differ from Nagata's. Indeed, if one were to eliminate the reference sensor from Dempsey, as taught by Nagata, Dempsey's sensor would no longer be operative for its disclosed purpose—i.e., stable zero-air operation under changing temperature conditions.

Specifically, Dempsey discloses that a reference electrode 11 is provided on the same surface as the sensing electrode to eliminate large background current variations with *temperature variations* during zero-air operations. *See*, Title; col. 1, lines 24-37; col. 2, lines 6-13; col. 4, lines 11-29; col. 4, line 67 – col. 5, line 5; and col. 6, lines 10-12 and lines 30-37. The reference electrode is positioned as close as possible to the sensing electrode, while being maintained remote from the flux lines between the sensing and counter electrodes, *so that the reference and sensing electrodes may be subjected to the same temperature conditions*. Col. 4, lines 11-29 and col. 6, lines 10-12. Dempsey uses a potentiostatic circuit to maintain the potential of the sensing electrode at a desired level and to maintain a fixed potential difference between the sensing electrode and the reference electrode to permit invariant and accurate operation with time and *with changes in temperature*. Col. 4, line 67 – col. 5, line 5.

In contrast, Nagata discloses a reference electrode to *maintain the potential at the surface of the working electrode, in order to account for a change in the potential of the counter electrode due to the oxidation and reduction reactions taking place*. Col. 5, line 65 – col. 6, line 12. Nagata does not disclose the use of a reference electrode to maintain the potential of the working electrode to account for changes in temperature. As Nagata uses a reference electrode for a different purpose than Dempsey uses a reference electrode, Nagata's disclosure that the reference electrode need not be used under certain conditions is inapposite to Dempsey's disclosure.

Further, significant differences in the functionality and the arrangement of the sensors preclude applying the teachings of Nagata to Dempsey. For example, Dempsey discloses a hydrated gas sensor for operation from 1°C to 40°C. In contrast, Nagata discloses a flammable gas sensor for operation from 100°C to 400°C. Also, Dempsey discloses that the sensing electrode 13 and the counter electrode 10 are arranged on opposite sides of the hydrated solid polymer electrolyte membrane and spatially aligned with one another. In contrast, Nagata discloses that the working electrode 2, the counter electrode 4 and, optionally, the reference electrode 3 are provided on a surface of an insulating substrate 1 and covered by a gas-permeable proton-conductive film 5. Nagata, thus, discloses that each of its electrodes is arranged on the *same side* of the gas-permeable proton-conductive film.

As the Examiner has recognized that Dempsey fails to disclose that the sensing electrode and the counter electrode are the only two electrodes, and as Nagata, as discussed above, fails to disclose that the reference electrode of Dempsey could be eliminated without disrupting the principle of operation of Dempsey, the combination of Dempsey in view of Nagata fails to render claims 66, 70, 72, 74 and 76 unpatentable.

#### **New Claims 128 – 132**

New claim 128 is essentially an amended version of claim 126, with the differences shown for the convenience of the Examiner as follows:

Claim 128. (New) A two-electrode residential electrochemical gas sensor for quantitative measurement of carbon monoxide gas in an ambient atmosphere comprising:

- a sensing electrode permeable to water vapor and comprised of an electrical conducting material and having a surface exposed to the ambient atmosphere;

- a counter electrode permeable to water vapor and comprised of an electrical conducting material;

- a first protonic conductive electrolyte membrane permeable to water vapor and situated between and in contact with the sensing and counter electrodes, the sensing electrode and the counter electrode being the only two electrodes in contact with the first protonic conductive electrolyte membrane, and the sensing electrode ~~being capable of~~ reacting with the carbon monoxide gas to produce a change in electrical



characteristic between the sensing electrode and the counter electrode in the absence of an applied voltage to the sensing electrode;

means for electrical measurement electrically connected to said sensing and counter electrodes;

means, containing a volume of water vapor, for exposing a surface of said counter electrode to said water vapor,

wherein the electrical conducting material of at least one of said sensing and counter electrodes is a proton-electron mixed conductive material having 10-50 wt % of a proton conductor material and 50-90 wt % of a first and a second electrical conductor material;

whereby, in a positive ambient atmosphere concentration of the carbon monoxide gas at room temperature, said electrical measurement means detects changes in said electrical characteristic;

wherein each of the sensing electrode and the counter electrode comprise a mixed protonic-electronic conductive electrode including platinum, carbon and a copolymer having a tetrafluorethylene backbone with a side chain of perfluorinated monomers containing a sulfonic acid group; and

wherein the protonic conductive solid electrolyte membrane is substantially comprised of a solid, perfluorinated, ion-exchange polymer.

Support for claim 128 can be found throughout the specification and, at least, in FIG. 2, col. 7, lines 3-10, col. 8, lines 8-20, col. 8, lines 21-34, col. 9, lines 41-58, col. 12, line 63-col. 13, line 17, and col. 14, lines 10-65.

New claims 129-130 depend from claim 128 and include further recitations to the thicknesses of the electrodes and the electrolytic membrane. Support for these claims can be found at least at col. 8, lines 37-41.

New claim 131 depends from claim 128 and includes further recitations to the proton-electron mixed conductive material. Support for new claim 131 can be found, at least, at col. 14, lines 10-65.

New claim 132 depends from claim 128 and includes further recitations to the relative humidity of the water vapor. Support for new claim 132 can be found, at least, at col. 7, lines 50-61.

**Evidence of Commercial Success**

Submitted herewith is the Applicants' Supplemental Declaration of Commercial Success Under 37 CFR § 1.132 (referred to herein as "Dr. Shen's Declaration" or the "Declaration"). This declaration, signed by Dr. Yousheng Shen, one of the named inventors of the '054 Patent, presents substantial new evidence that the invention described and claimed in the '054 Patent has been highly successful in the marketplace. In addition, the Declaration sets forth a detailed explanation of the significant advantages of the claimed invention. Applicants respectfully request reconsideration based on this newly available objective evidence of nonobviousness.

Even after the Supreme Court's *KSR* decision, a determination of obviousness requires adherence to the following tenets: (1) the claimed invention must be considered as a whole; (2) the references must be considered as a whole and must suggest the desirability and thus the obviousness of making the combination; (3) the references must be viewed without the benefit of impermissible hindsight afforded by the claimed invention; and (4) reasonable expectation of success is the standard with which obviousness is determined. See *Hodosh v. Block Drug Co., Inc.*, 786 F.2d 1136, 1143 n.5, 229 USPQ 182 187 n.5 (Fed. Cir. 1986). Application of the proper obviousness standard does not lead to the conclusion that one of skill in the art at the time the invention was made would be prompted to combine these references in order to make the invention defined by the claims.

Dr. Shen's Declaration, which constitutes substantial new objective evidence of nonobviousness, was not considered by the Board. This new evidence, which evidences commercial success after 2003, was not available prior to the briefing of the appeal, and only became available during the pendency of the appeal. This new objective evidence of commercial success, involves, in large part, sales of sensors within the scope of the subject claims during the time period following close of ex parte prosecution prior to the appeal.

As noted in sections 9 and 10 of Dr. Shen's Declaration, commercial embodiments of the claimed invention manufactured by Atwood's licensee under the '054 Patent exhibit many improvements over prior art CO sensors, including: reliable

operation at room temperature; no need to recalibrate; no power consumption for the sensors, themselves; improved CO detection accuracy; and lower cost of manufacture.

These commercial advantages are made possible by the following technical performance properties described in the '054 Patent:

- a. minimal ionic ( $H^+$ ) resistance between the electrodes without significant diffusion of contaminating hydrogen molecules;
- b. rapid response to CO in ambient air;
- c. strong current signal output in response to detection of CO;
- d. no need for periodic re-calibration of the sensor;
- e. use of a solid electrolyte, resulting in reduction/elimination of background drift or countersignal caused by contamination of electrolyte or the water vapor source;
- f. avoidance of long term stability problems in prior art devices;
- g. short ion path and solid state protonic and ionic conductivity, eliminating the need for the reference electrode and amplifier (and thereby eliminating any need for applied DC power to drive the detection current) in the prior art; and,
- h. continuity in transport of electrical charges to avoid polarization effects at the electrodes.

These properties are all interrelated and result from the inventive geometry and selection of materials described in the '054 Patent and recited in the subject claims.

In section 10 of Dr. Shen's Declaration, Dr. Shen relates these technical improvement properties to the recitations of the claims. As an example, Dr. Shen relates the fact that the CO Sensors operate reliably at room temperature to the claimed features of the sensing electrode, the counter electrode and the membrane each including a protonic conductor; the use of mixed ionic-electronic conductive sensing and counter electrodes; and the sensing electrode, the counter electrode and the membrane each being permeable to water vapor. These features result in an optimized free ion path that results in results in minimal ionic ( $H^+$ ) resistance between the electrodes and a high surface area for three-phase interface contact to occur. The result is a stronger current signal output

than is available in the prior art (without requiring the use of amplifiers or reference electrodes).

Further, because of the stronger current signal output (without the use of amplifiers or reference electrodes), the CO Sensors, themselves, do not consume any power. Thus, the inventive combination of features eliminates the need for any applied DC power to drive the detection current. This, then results in a cheaper and easier to manufacture CO Sensor.

Similarly, the claimed combination of features leads to a rapid response at room temperature in ambient air and the avoidance of polarization. Even further, the claimed combination of features leads to a reduction in background drift, such that the need for periodic re-calibration of the sensor is eliminated. Thus, long term stability problems are avoided, and again, the CO Sensor may operate without a reference electrode.

As the claim recitations directly result in every single technical performance property listed in the declaration, a nexus between commercial success and the claimed invention has been proven.

Further, Dr. Shen's Declaration notes that the '054 Patent (and another closely-related patent currently undergoing reissue) are the subject of a royalty-bearing license agreement entered into in June, 1998. The license is an arms-length agreement between separate corporate entities. Pursuant to the license, Atwood (the assignee of the '054 Patent) has received royalty payments and royalty reports based on the number of sensors sold by the licensee. (See Dr. Shen's Declaration at section 11). The licensed product was immediately successful, achieving sales of 1,991,639 units in 1999, the first full year under the license agreement. Sales continued to grow thereafter, reaching 2,717,913 units in 2001. (Dr. Shen's Declaration at section 12). This was the extent of the sales information available at the time of briefing of the appeal in the '209 Reexam.

Sales of the licensed product continued to skyrocket in the years of the appeal pendency in the '209 Reexam. Dr. Shen's Declaration sets forth the data unavailable during the appeal period showing that, from 2002 through 2006, total royalty payments under the license agreement amounted to over \$3.9 million. (*Id.* at paragraph 10). Dr.

Shen confirms in his declaration that the licensee's licensed CO Sensor product embodies the limitations of at least Claim 1 and Claim 128 of the '054 Patent. (*Id.* at section 8).

It is well established that commercial success is relevant in resolving the issue of non-obviousness. *Lindenmann Maschinenfabrik GMBH v. American Hoist & Derrick Co.*, 730 F.2d 1452, 221 USPQ 481 (Fed. Cir. 1984). It is also well established that licensing activity, e.g., licensing agreements, is an indicator of non-obviousness. All objective evidence must be properly considered in determining whether claims are non-obvious.

It is clearly evident that the commercial success of the patented CO Sensor product sold pursuant to the license agreement is directly attributable to the advantageous features set forth above, and particularly the advantages of reliable operation at room temperature, without need for recalibration or frequent battery changes, and reduced cost of manufacture, as described and claimed in the '054 Patent. (Dr. Shen's Declaration at sections 9 and 10).

In view of the strong objective evidence of commercial success and significant advantages achieved over the prior art, Applicants' respectfully submit that claims 1 – 67 and 70 – 132 in this Reissue application are all patentable over the art of record.

### **Conclusion**

Applicant respectfully requests entry of the above amendments and reconsideration of the claim in light of the entirety of the evidence presented herein.

Applicant hereby petitions for a three-month extension of time under 37 C.F.R. 1.136(a). The Commissioner is hereby authorized to charge such extension fee or credit any overpayment of fees to Deposit Account No. 19-0733.

Respectfully submitted,  
Shen et al.

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